Non-Llinear Four-Wave Interactions

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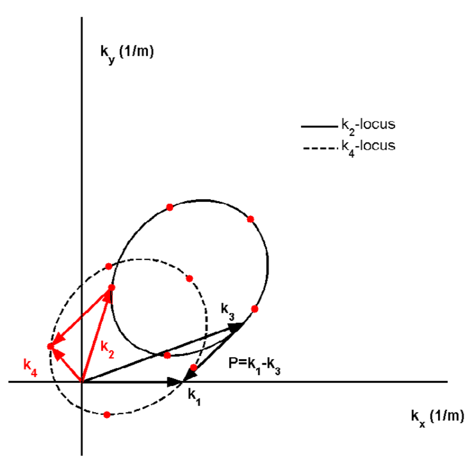
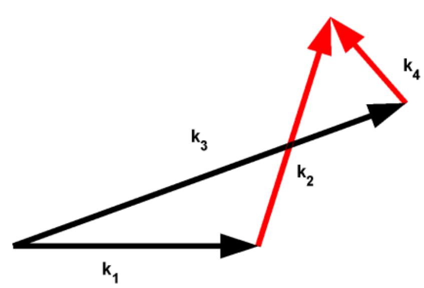
A scalable parameterization of non-linear four-wave interactions is being developed to bridge the gap between time consuming exact methods and the fast but in accurate Discrete Interaction Approximation (DIA). Various approaches have been explored to bridge this gap. The first approach is to extend the classic DIA with additional configurations, but this approach is not trivial as no simple procedure exists to define a “next best” set of wave number configurations. It should be remarked that the GDIA developed by Tolman is a major in step in this direction, but its derivation requires large computational resources and each set may depend on physical and numerical wave model settings with which it is derived. The other approach is to start with the full exact solution and strip it down following a mathematical consistent way. This approach is now explored on the basis of the WRT method using various paths.

The **first** path is to limit the integration space by applying higher integration methods, filtering methods, simplified interpolation procedures and resampling of the points on the locus. This approach has been tested using a two-week hindcast on Lake Michigan using the 0-d SWAN model, developed by Erick Rogers of NRL. This investigation led to more practical, but still time consuming, settings of the WRT method for application in operational wave models. The **second** path is based on the Lumped Quadruplet Approximation, in which contributions on the locus can be regarded as an individual wave number configuration which can be handled by the Generalized Multiple DIA Approaches developed by Van Vledder and Tolman. Using this technique various sets of wave number configuration could be derived, but some details of the scaling need to be worked out. Modifications have been made to the WRT method to include the LQA. The figures below illustrate the principle of this approach.





A **methodology** has been described for the derivation of approximations of non-linear transfer integral in which the concepts of efficiency and accuracy are key components. Depending on the application of the non-linear term a distinction should be made on accuracy of the non-linear term or on the accuracy

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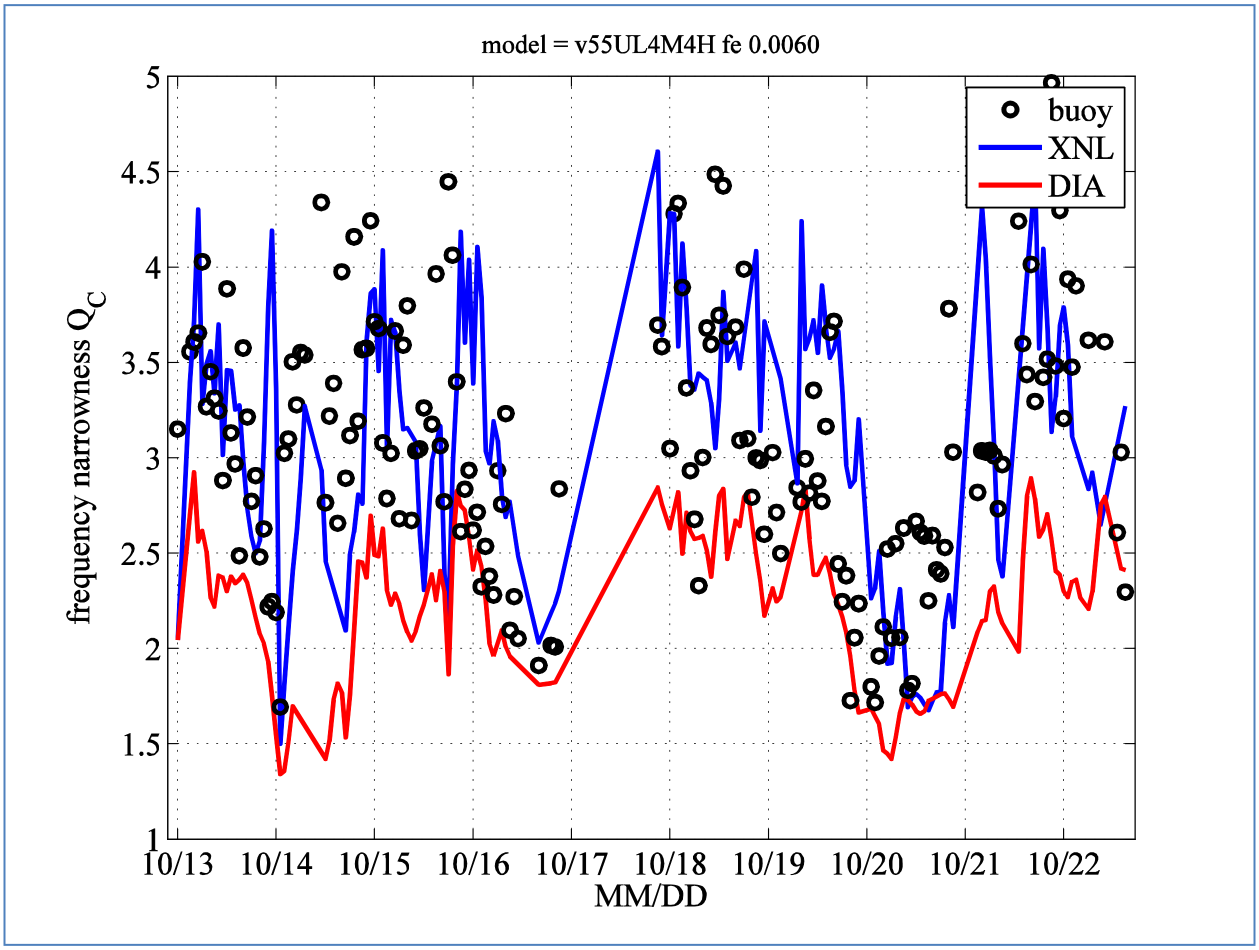
of overall wave model of which the non-linear term is only a part. This methodology has been presented at the Ocean Wave Workshop held at ECMWF, Reading, UK in June 2012. The accompanying paper is mentioned in the list of references.

The **importance** of replacing the DIA with something more accurate, on the spectral narrowness of the frequency spectrum has been studied in collaboration with Erick Rogers. To that end a 2 week period in Lake Michigan has been hindcast using a research version of the SWAN model using both the DIA and the WRT method. In addition, an analysis has been made which spectral parameters can best be used to quantify spectral narrowness (or alternatively its width). The resulting publication is now under review for publication in Ocean Modelling.



Comparison of measured and computed spectral narrowness using SWAN and two methods for computing the non-linear interactions. Period 13-22 October 2002, Lake Michigan (from Rogers and Van Vledder, 2012).

The development of new approximate methods to solve the nonlinear transfer integral requires a reliable benchmark. Presently, three main approaches are known. These are the WRT method as implemented by Resio and Perrie, and Van Vledder; Masuda's method implemented in the RIAM method by Komatsu; and the method of Lavrenov implemented as the GQM by Benoit and Gagnaire-Renou (See Van Vledder, 2012 for further details of these methods). Although each of these methods aims to solve the same integral, no guarantee can be given that they provide the same answers.

Therefore, an inter-comparison study is under way to objectively compare these methods. Prime participants in this study are Van Vledder (WRT), Hashimoto (RIAM) and Benoit (GQM).

Further analyses and collaborations are in preparation regarding shallow water effects on the nonlinear transfer rate based on the work of Janssen and Onorato, and the effect on instationarities in the wave field following the work of Gramstad and Stiassnie.

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